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CITY STREET DUST AND INFECTIOUS DISEASES¹

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The congestion of population within filthy and ill-kept quarters has created many problems concerning public health that practically are unknown in rural communities. Pollution of the air and of drinking water is responsible for a considerable proportion of the death rate in almost every part of the world; in cities, however, the death rate is materially affected by the pollution of the air from causes that are remediable.

In 1917, a year free from epidemic diseases in the United States, and therefore a fair criterion, the crude death rate varied from 8.6 per 1,000 in Seattle, to 23.1 per 1,000 in Trenton, New Jersey. Had the death rate of Trenton been reduced to that of Seattle, the saving of lives would have been about 1,900; and had the death rate of Seattle been as great as that of Trenton, the toll would have been in excess of 5,000 lives. Comparing the rate of infant mortality with that of the general rate, about three fourths of the number would have been babies under two years of age.

In New York City a change in the method of cleaning the streets, washing hard-paved streets instead of dry-sweeping them, was followed at once by a lowering of the death rate. In several western cities the abolition of dry-sweeping for sanitary methods of cleaning the streets produced similar results. There are no specific statistics whereby the deaths due to polluted air may be separated from those due to other causes, but one can not ignore the unqualified opinions of health officials whose knowledge in the matter is positive.

¹ The statistics concerning the bacteriological content of the air are mainly on the authority of the following:

WINSLOW, C.-E. A., and KLIGLER, I. J., "Quantitative Study of the Bacteria in City Dust." *American Journal of Public Health* [Vol. 2, No. 9].

PRUDEN, T. MITCHELL, "Dust and its Dangers." G. P. Putnam's Sons.

KENWOOD AND PARKS, "Hygiene and Public Health." P. Blakiston's Son & Co.

Bacteriological research is not carried on in this laboratory except in an incidental and rather crude way. Microorganisms are merely a part of the dust content of the air.

City dust is the offal of an overcrowded population—paving stuff, horse dung, ashes, garbage in every stage of putrefaction, the dismembered anatomy of insects and the refuse of humanity—all ground to fineness. When reduced to microscopic size it is ready for distribution; and the diffusion of city street dust is a striking example of perpetual motion. Street traffic is the chief factor in the creation of city street dust; the rattan broom, wind, and human footsteps are the chief agents whereby it is diffused.

Wherever air currents exist in crowded localities they carry city street dust. Air currents carry dust by means of wind pressure through cracks and crevices which water will not penetrate. In a box, within another box, within a closet of this laboratory, were some vulcanite cells that had lain undisturbed for more than two years. When an occasion for their use occurred, they were covered with a gray film of dust. A quarter-inch objective showed that the dust consisted of ash from the heater, horse dung, and a few bits of wool fiber. Meteorologists sometimes discuss the properties of still air. But still air does not exist. Air currents may be strong enough to pick up, or to carry, or to drop dust; all the time they are doing the one or the other. In this particular instance lowering temperature or increasing pressure, or both, had forced dust-laden air into the box; increasing temperature or decreasing pressure in turn had forced air out of the box but the outgoing air did not overcome the adhesion of the dust to the cells. Similar movements are going on all the time. The house is merely a box into which air is forced at one time and out of it at another. Dust that settles is apt to adhere strongly. The air that goes into it is dust-laden; the air that goes out leaves the dust behind.

In city streets the rolling dust is rarely carried more than a foot or two from the ground. This slight lift, however, is sufficient to dump it into cellars, into basements, and into the intakes of ventilating chambers. Coarse dust is rarely carried above a few hundred feet, and insects are not carried higher. Even the finest street dust is not whisked more than twelve hundred or fifteen hundred feet above ground by the wind. The danger zone, therefore, is close to the ground, so far as wind-blown dust is concerned. These statements, one must bear in mind, do not apply to the floating dust of the upper air,² or to the region of convection; they refer to the shell of wind-blown dust only.

Probably the greater part of the dust which gets into a building is "tracked" into it. Dust blown into the air is constantly settling, and a due proportion settles on sidewalks and approaches. This dust is ground finer and finer by scuffing feet and by attrition of other kinds. Within a very few minutes after the pupils of a city public school have marched through the corridors of the building the flying dust sometimes exceeds 80,000 par-

² The floating dust has been discussed in a previous paper, "The Dust of the Upper Air" in *ECOLOGY*, Vol. II, No. 2, pp. 104-109, for April, 1921.

ticles per cubic inch of air. Most of this dust has been tracked into the building. The imprint of a shoe fresh from the sidewalk on a piece of black cloth leaves from several hundred to several thousand dust particles per square inch.

Large dust particles—that is, those exceeding four or five micromillimeters in dimension—are not especially harmful. They are too large to become entangled in lung tissue. Even those small enough to become entangled in the lungs, are not especially harmful unless sharp-edged, such as drill dust, or grinders' dust.

The chief menace of street dust is its biological content—the presence of the microorganisms popularly known as “germs.” Years ago, Dr. T. M. Prudden carried on a series of tests on the biologic content of the air. Thereby he gave a very black eye to the commonly accepted notion that air and sunlight are positively destructive to microorganisms. The theory is true in part but the exceptions are important. The tests made by Winslow and Kligler, as well as the information gathered from many other sources show that microorganisms may survive in air and in dust from a few hours to many days. The important feature is the fact that definite knowledge concerning the why and the wherefore for the difference in the period of survival does not exist. Public safety depends on the assumption that, unless sterilized, dust of any sort possesses the possibilities of infection.

The broader knowledge that Prudden emphasized is even more definite and of greater value than the specific facts which he demonstrated. His methods involved a rare combination of simplicity and practical sense. He plated shallow dishes with culture media and exposed them under standard conditions to the air. Microorganisms that fell on a culture medium very quickly developed colonies. The remaining work was the count of the colonies.

The next step was the determination of the effect of air currents. So far as the movement of visible dust particles is concerned, air moving so slowly that it will not deflect the direction of smoke may be considered as still air. Here are the results obtained by Prudden from the five-minute exposure of plated Petri dishes $3\frac{3}{4}$ inches in diameter:

1. In a private residence.....	34 colonies
2. In a department store.....	199 “
3. At Union Square.....	214 “
4. At an entrance to Central Park.....	499 “
5. At Broadway and Thirty-fifth Street.....	941 “
6. Where street-sweepers were at work.....	5810 “

The moral is obvious: A light breeze whisks comparatively few microorganisms into the air; heavy and fast-moving traffic flings up a much greater quantity. But evidently winds and busy street traffic are in the kindergarten class compared with the street-sweeper's rattan broom. Even

granting that the totals are merely rough approximations, the ratios have real values. They indicate that dry-sweeping with its consequent cloud of dust is the chief factor in air pollution. The broom sends five times as much dust into the air as does heavy street traffic, and ten times as much as a light breeze.

Winslow and Kligler strengthened Prudden's conclusions by counting the number of microorganisms in street dust. The tests ranged from 150,000 to 145,000,000 per gram. The average was more than 20,000,000 for out-of-door dust and about 5,000,000 for indoor dust. The number is much greater in water-sprinkled than in unsprinkled streets. The statistics gathered from various other sources in American and European cities gave values which were not materially different.

What is the effect of such contamination on public health? The answer is not easy. One may readily conceive a danger that does not exist; one also may ignore a danger that does exist. As a matter of fact,, humanity has been breathing polluted air for many centuries. In general, emphasis has been placed on the presence of carbon dioxide in the air and not on the dangers arising from its dust content. The evils consequent upon an excess of carbon dioxide in the air have proved something of a bugaboo. The possibilities of infection from dust pollution, long ignored, have been shown to be real and serious. Modern sanitary science has accomplished wonders in the prevention of infectious and contagious diseases. Much still remains to be done if the death rate is to be lowered. The urban death rate has been lowered little by little until, in many instances, it is lower than that of nearby rural communities. There is, however, a tremendous difference between 6.9 per 1,000 and 23.1 per 1,000.

Most of the microorganisms found in street dust are harmless. Some, like the colon bacilli, are in the class of "suspects," still others are disease-bearing and deadly. The colon bacillus is almost universal where animals are used in street traffic. It is intestinal in origin and is abundant in the fecal discharges dropped upon streets. As a part of the content of city street dust colon bacilli do not indicate the presence of typhoid bacilli.³ Winslow and Kligler found the ratio of colon bacilli to other microorganisms somewhat greater than 1:1,000; in one instance the number exceeded 60,000 per gram. Their number in indoor dust averaged about one fourth that in out-of-door dust. Redway found them in the dust of various school rooms; in a public library; and on fruit exposed for sale on a public street. In medical science they are regarded as harmless under ordinary circumstances, but at times they are virulent.

The streptococcus is sometimes found in the horse-dung content of street

³ If found in water supplies situated at a distance from public streets colon bacilli indicate fecal contamination. In such cases the water may or may not be infected with the bacilli of typhoid.

dust; for the greater part it is a product of human carelessness, due to the habit of promiscuous expectoration. Streptococci in street dust therefore are presumably of buccal origin. In themselves they are not regarded as harmful. If they are of buccal origin, however, they indicate the probability of pathogenic microorganisms that infest the human mouth.

Of the presence of tubercle bacilli in street dust there is no question. The research of many years, covering practically all the large cities of Europe and America, show that they are rarely absent. Although street dust moves normally from out of doors to indoors, it is probable that tubercle bacilli accumulate indoors and are carried out of doors. The statistics gathered by Winslow and Kligler show that, while only about 5 percent of the microorganisms in the dust of non-infected localities are tubercle bacilli, in infected localities the proportion is five times as great. Still further, the same authors find that, while in non-infected localities only 8 percent of the animal deaths from all causes is due to tuberculosis, in infected localities about one third died from that disease. Again granting that such values apply only to the localities in which the tests were made, the results show conclusively that infection from dust is not only possible but that it may be certain. So far as Europe and the United States are concerned, tuberculosis is not only pandemic; it is always with us; and although the death rate has been lowered, the total number of deaths therefrom has increased during a period of twenty years. And a reason therefore is not hard to find. Even if all other sources of infection be eliminated, street dust is competent to keep the disease with us. In the spread of microorganisms by means of air currents, Dr. Winslow gives first place to the "March gale." One might add that, if the velocity of an air current is doubled its capacity as a carrier of loose dust increases sixty-four-fold. Even with this capacity it is doubtful if a brisk breeze puts anything over the street sweeper's rattan broom. Either one is fully competent to account for the persistence of tuberculosis.

The microorganisms of anthrax and tetanus are spore-forming; hence theoretically the greater possibilities of infection by means of the air. As a matter of fact, evidences of infection by air contact are absent so far as available statistics are concerned. The health statistics of New York City show that, in the metropolitan district, the shaving brush is the chief source of anthrax infection. Winslow's statistics show that dust from dry hair and hides are responsible for many, if not most of the cases elsewhere.

Street dust is a very far-reaching factor in epidemiography. Whenever infectious diseases hover over a locality, the street dust there is apt to contain the microorganisms of the disease. In the vicinity of hair and hide industry, the bacilli of anthrax are usually discoverable in nearby dust. Neustaedter and Thro produced poliomyelitis from the dust of an infected sick room. Research in various parts of the United States and Europe

shows that, at times, the pneumococcus is discoverable in dust, indoors and out of doors. The bacillus of diphtheria has also been found in street dust, but its presence seems to be rare. Cases of infection by house dust are common. The microorganism of influenza, of the bubonic plague, and of Asiatic cholera do not seem to occur in street dust. They seem to have but little resistance to dry air and dust. Evidence of the existence of the typhoid bacillus in dust seems to be doubted by some bacteriologists. There are possibilities, however. The dismembered anatomy of flies is almost always discoverable in city street dust in the localities where flies are abundant. If the flies have fed on contaminated excreta, typhoid bacilli will be found in their remains. The rest is merely a question of the resistance of the bacilli.

More and more the evidence that still, dry air has but little power to convey the germs of disease is strengthening. Moist air frequently contains microorganisms; perhaps some of them may be pathogenic, but evidence at present available does not support such a hypothesis. All the evidence so far obtainable indicates that infectious air is dust-laden air. No suspicions obtain against the upper air and its dust content so far as the communication of disease is concerned. It is not much of an exaggeration to say that all the disease-bearing dust is in the neighborhood of over-populated localities and below the 1,200-foot level of the air.

Sanitation of the air concerns its proper humification and its cleanliness. Proper humification of the air indoors is not a difficult matter. Control of its dust content is more difficult. Dust may be taken from the air, it is true; it is an interesting scientific experiment. It is likewise comparable to the use of a locomotive to carry a postage stamp from Quoddy Head to Cape Mendocino. It can be done. Prevention, however, is not only possible; it is practicable. Varnishing or oiling floors will keep the dust of indoors out of the air. And when the dust is not in the air no one is breathing it. Screening the air supplied to mechanically ventilated buildings removes the greater part of the dust; washing the air—now a practice in many public buildings—removes the rest. Washing hard-paved streets not only prevents the dust from flying into the air, but also removes it beyond the possibility of doing harm. Tarring the street which this laboratory faces reduced the flying dust about 95 percent—more rather than less. Indeed anything which eliminates the rattan broom of the street sweeper is a blessing to all humanity unfortunate enough to be within the confines of dust-laden air.

“Public health is a purchasable commodity. Within natural limits a municipality may fix its own death rate.” And human life is the price which a community pays for indifference and ignorance.